(12) UK Patent Application (19) GB (11) 2 323 056 (13) A

(43) Date of A Publication 16.09.1998

(21) Application No 9705283.1

(22) Date of Filing 14.03.1997

(71) Applicant(s)
GKN Westland Helicopters Limited
(Incorporated in the United Kingdom)
Box 206, Westland Works, YEOVIL, Somerset, BA20 2YB, United Kingdom

(72) Inventor(s)
John William Damon
Dennis Pugsley

(74) Agent and/or Address for Service
Forrester Ketley & Co
Chamberlain House, Paradise Place, BIRMINGHAM, B3 3HP, United Kingdom

(51) INT CL[6]
B29C 70/54 // B29K 105:06 , B29L 31:30

(52) UK CL (Edition P)
B5A AT20P A1R214G A1R314C2X A1R422 A2A1 A2G
U1S S1417 S1854

(56) Documents Cited
GB 2256611 A GB 2025302 A GB 1352198 A
EP 0471459 A1 US 5246520 A US 4486372 A

(58) Field of Search
UK CL (Edition O) B5A AA2 AT12A AT12P AT20P AT9P
INT CL[6] B26F 1/24 , B29C 33/00 67/14
Online:WPI

(54) Abstract Title
Method of forming a composite panel provided with a plurality of holes

(57) A method of providing a panel (12) of composite material with a plurality of openings comprising the steps of laying the panel (12) on a base (11), placing on the panel (12) a plurality of pins (13) held in a matrix 14 with each pin (13) being transverse to the panel (12), causing the pins (13) to pass into the panel (12), and subsequently removing the pins (13) from the panel (12) by chemical etching with an etching chemical which is inert to the composite material.

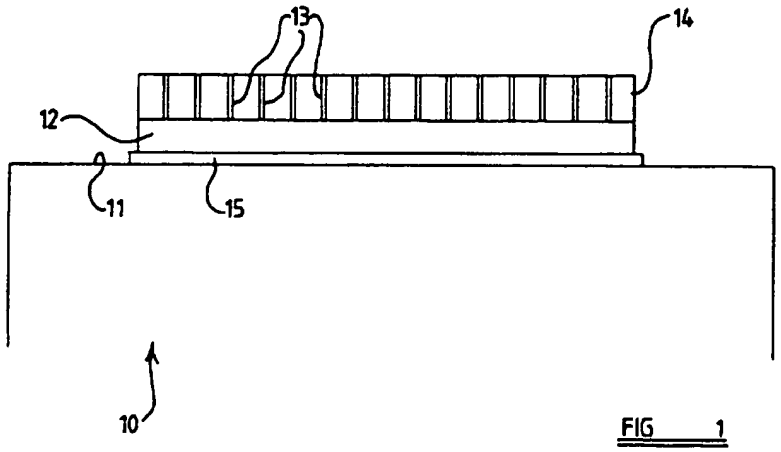

FIG 1

GB 2 323 056 A

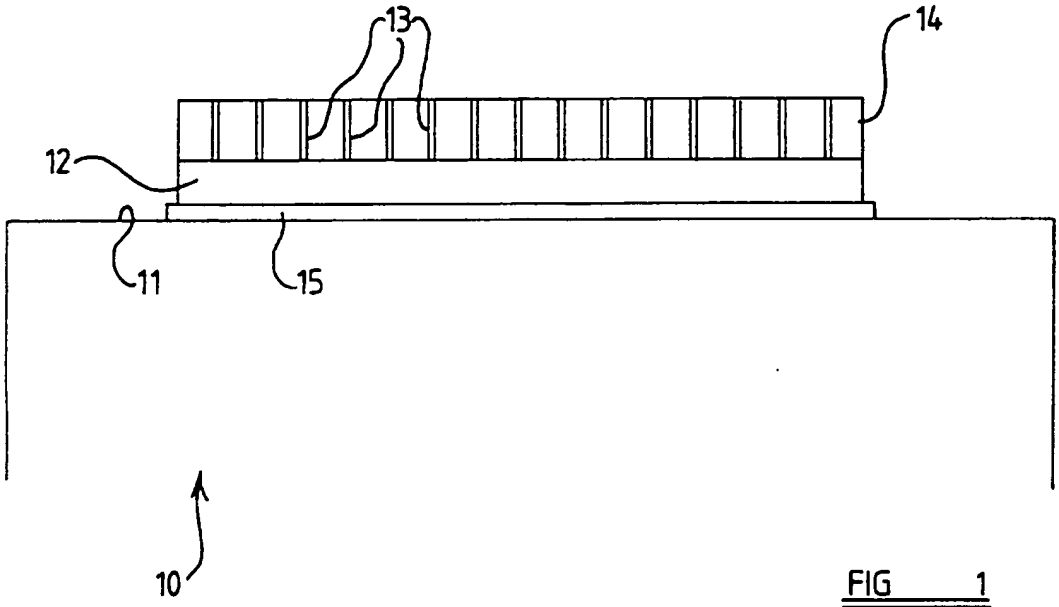

FIG 1

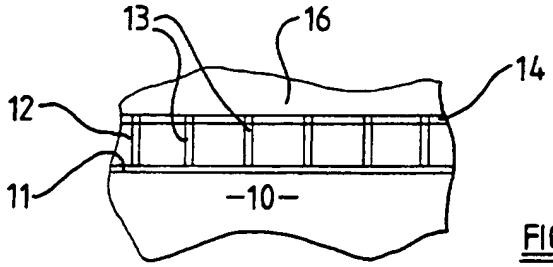

FIG 2

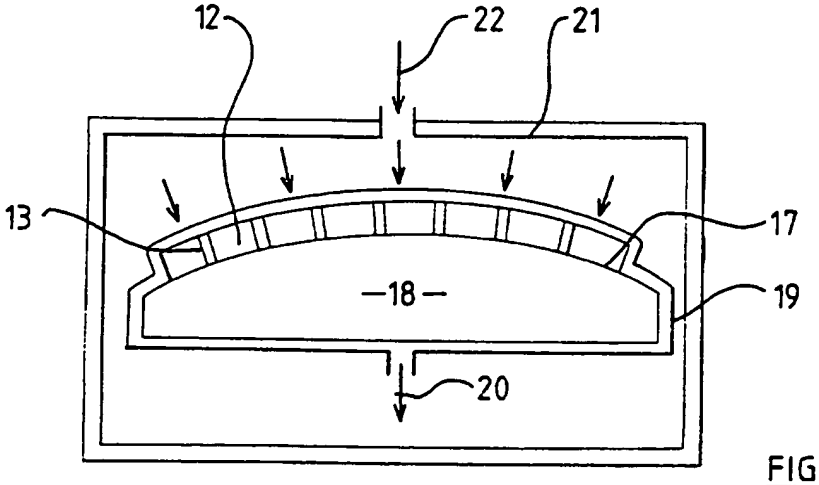

FIG 3

Title: **Method of Providing a Panel of Composite Material with a Plurality of Holes**

Description of Invention

This invention relates to a method of providing a panel of composite material with a plurality of openings, and more particularly but not exclusively to a method of providing a panel of composite material as a skin for use on an engine nacelle, which skin has a plurality of openings in strategic positions, for use in engine noise reduction.

At present it is common practice to manufacture a skin for an engine nacelle in metallic material, from pre-drilled metal sheet. The metal sheet is pre-drilled in strategic positions and is shaped e.g. by wheeling and working, around a former, usually of double curvature shape, to the desired shape. The skin thus formed is then structurally bonded to a honeycomb core to form an acoustic lining. In use, noise from the engine enters the openings and the cells of the honeycomb structure act as anechoic chambers, so as to reverse the noise back to the engine.

An example of an acoustic lining for an engine component is described in GB2038410.

The drawbacks of this method are that the openings tend to become deformed as the metal sheet is formed to shape thus detracting from the efficiency of the skin in reducing noise, and the raw materials are expensive and heavy. Heavy materials are to be avoided particularly where the engine is an aircraft engine.

A method of producing composite double curvature skins for use on engine nacelles for noise reduction has been long sought after. Although it may be possible to form composite material to the desired shape and subsequently drill the openings, the machining would be expensive. Furthermore, fibres in the composite material can be cut and exposed by drilling, and such exposed fibres

can detract from noise reduction efficiency. Thus providing openings in strategic positions by this method can be a long and complicated procedure.

According to the invention we provide a method of providing a panel of composite material with a plurality of openings comprising the steps of laying up the panel in an uncured or not fully cured state, on a base, placing on the panel a plurality of pins held in a matrix with each pin being transverse to the panel, causing the pins to pass into the panel, curing or further curing the panel and subsequently removing the pins from the panel by chemical etching with an etching chemical which is inert to the composite material.

Thus the pins may conveniently be removed from the cured panel however complex the panel shape, even where the panel is of double curvature shape, without risk of distortion of the openings. Because the composite material is not drilled there is no risk of reinforcing fibres being cut and exposed.

Conveniently the matrix comprises a foam-type material with the plurality of pins embedded in the foam.

The matrix material which holds the pins may become adhered to the panel in use and may be substantially removable e.g. from the panel prior to the pins being removed from the panel. For examples, the material may be removed by applying heat, and/or by chemical means, and/or by soaking and/or by blasting with a suitable medium.

Although the pins may be removed by any suitable etching chemical, the pins may be removed by chemical etching using a strong acid.

The pins may be caused to pass into the panel by any known means, such as by driving into the composite panel using a wheel or roller, and/or an impacting means such as an ultrasonic gun or a press.

Preferably the base is a generally flat base and the composite panel is removed from the base after the pins have been passed into the panel and placed on a surface of a moulding tool for subsequent curing to the desired shape. Alternatively the base may comprise a surface of a moulding too. In each case a protective sheet may be placed between the base or tool surface and the

composite panel placed thereon, so as to protect the base or moulding tool from the pins damaging the surface thereof and to prevent the foam or other matrix material bonding to the base.

The composite panel may be a skin of an engine nacelle and the panel may , subsequent to the pins being removed therefrom, be attached to another component part of the nacelle, such as a honeycomb core structure.

Although usually the composite material of the panel would comprise reinforcing fibres embedded in a resin material, the invention may be applied where the composite material of the panel is a composite of plastics laminates for example only, or of other materials.

The invention will now be described with reference to the accompanying drawings in which,

FIGURE 1 is an illustrative sectional side view of an apparatus for use in performing the first step of the method of the invention;

FIGURE 2 is a fragmentary view of part of Figure 1 showing a further step, and

FIGURE 3 is a sectional side view of apparatus used in a further step.

Referring to Figure 1 there is shown part of a base being a tool 10 for use in laying up a panel of composite material having provided therein a plurality of strategically positioned openings. The panel when produced, forms an inner skin or lining of an engine nacelle and is bonded to another nacelle component comprising a honeycomb core structure, using for example, a reticulating adhesive although any other means for attaching the skin to the another nacelle component may instead be used.

Tool 10 has a flat upper surface 11 on which an incurred composite panel 12 is layed up. Typically the panel 12 comprises between two and four plies of fibre reinforced plastics material each about 0.010in (0.25 mm) thick making a total thickness of between .020 and .040 in (0.5-1.0 mm).

The method of the invention may be performed as follows.

First, a matrix of opening forming metallic pins 13 is located on the

layed up panel 12. Conveniently, the matrix of pins 13 is provided embedded in matrix material 14 which holds the pins 13, which material 14 subsequent to use, is readily removable from the formed panel 12, as hereinafter described. In the example illustrated, the material 14 comprises a plastic foam, and such material 14 with embedded pins 13 is available and is known as "Z-Fibre" which is a trade mark of Aztex Inc. Z-Fibre is conventionally used to provide a matrix of small diameter pins which are driven into a composite workpiece for reinforcing the workpiece, e.g. to prevent delamination or to strengthen a joint. The pins are thus conventionally left in the workpiece to perform their function.

The diameter and pitch of the pins 13 will be selected to suit the purpose for which the finished panel 12 is to be used. For example, for the described use as the inner skin of an engine nacelle, the pins 13 may be about 0.040 in (1.00mm) diameter with a pitch between pins 13 of between 0.160 and 0.20 in (4.0 and 5.0mm)

A protective layer 15 may be applied to the tool surface 11. This may conveniently be a layer of silicone rubber which has two protective functions. First, the layer 15 prevents the uncured composite panel 12 which subsequently is laid on the tool surface 11 from adhering thereto, and second, the protective layer 15 protects the surface 11 from damage as the pins 13 of the matrix are driven into the composite panel 12.

Pressure is then applied to the external surface of the matrix material 14 such as by a mechanical press 16 (Figure 2) to crush the foam and drive the pins 13 through and into the composite panel 12. It will be appreciated that the foam 14 holds the pins 13 upright so that they locate in panel 13 in a generally normal direction to the local area of the surface of the panel 12. The required pressure can be applied by other suitable means for example by hand using any appropriate tool such as an ultrasonic gun, or a roller or the like.

The foam material 14, or at least any remaining foam material 14, is removed from the uncured composite panel 12 e.g. chemically, or by soaking in a suitable solvent, and/or by blasting with suitable medium.

The uncured composite panel 12 is removed from the surface 11 of the laying up tool 10 with the pins 13 in place and is then draped on the curved surface 17 of a moulding tool 18 (Figure 3). It will be appreciated that the surface 17 may have a double curvature both across the page as shown in Figure 3 and into the page, corresponding to the desired shape of the finished panel 12. Again, a protective sheet may be placed between the uncured composite panel 12 and the moulding tool 17, if desired.

Composite panel 12 is then fully cured by the application of heat and pressure in a conventional manner. In the illustrated embodiment the moulding tool 18 and uncured panel 12 is first enclosed in an airtight bag 19, which is then evacuated by connection to a source of vacuum as indicated at 20. This holds the uncured panel 12 in position on the moulding tool 18 and provides some pressure to commence consolidation of the plies of the panel 12.

Moulding tool 18 is then moved into an oven 21 in which heat and pressure are applied fully to consolidate the plies and cure the thermosetting resin. In the illustrated embodiments a source of heated pressurised air 22 is connected to the interior of the oven 21 although it will be appreciated that other heater means such as electrical heaters could be used in place of or in addition to the heated air.

Once the panel 12 is fully cured, the moulding tool 18 is removed from the oven 21, the vacuum 20 is released and the bag 18 removed. The fully cured panel 12, still including the pins 13, is removed from the moulding tool 18.

The pins 13 are then removed from the composite panel 12 by chemical etching, using for example only, a strong acid to which the composite material of the panel 12 is inert. Thus holes are left through the composite panel 12.

The composite panel 12 may then be trimmed as necessary and bonded or otherwise attached to the honeycomb core cell component to complete the engine nacelle skin structure.

Various modifications are possible without departing from the scope

of the invention.

For example, although the invention has been described for making skins for engine nacelles, the invention may otherwise be used in any application where it is desired to provide a plurality of holes through a composite material.

The Z-Fibre material mentioned is an example only of a matrix material for retaining a matrix of pins. Other means for holding a plurality of pins in a matrix may be used. The pins need not be of circular cross section as inferred above, by particularly in another application may be of another cross sectional shape.

It will be appreciated that for some applications, for example in the production of a flat composite panel, the fibre reinforced layers may be layed up directly on a surface of a moulding tool. In such an application it may be beneficial to protect the moulding tool surface from damage when the pins are driven through the panel by the use of a silicone rubber sheet beneath the composite lay up.

In an unillustrated further embodiment, for some applications it may be that the pressure applied to the incurred lay up during the bagging and curing process may be sufficient to crush the matrix material 14 holding the pins 13 and to drive the pins 13 through the panel 12. In the use of such a process for a cured panel, the matrix material 14 holding the pins 13 may preferably be preformed to the cured shape such as by heating or alternatively, may be manufactured in such a manner so as to conform naturally to the required cured shape.

Thus, whereas it is preferred to cause the pins to pass into an uncured composite panel 12, in some circumstances the panel 12 may be partially cured, in which case the panel 12 may be further cured preferably until it is fully cured, prior to chemical etching to remove the pins.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process

for attaining the disclosed result, as appropriate, may, separately or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

CLAIMS

1. A method of providing a panel (12) of composite material with a plurality of openings comprising the steps of laying up the panel (12) in an uncured or not fully cured state, on a base (11), placing on the panel (12) a plurality of metal pins (13) held in a matrix (14) with each pin (13) being transverse to the panel (12), causing the pins (13) to pass into the panel (12), curing or fully curing the panel (12), and subsequently removing the pins (13) from the panel (12) by chemical etching with an etching chemical which is inert to the composite material.

2. A method according to claim 1 characterised in that the pins (13) are held in the matrix by a material (14) which is substantially removable from the panel (12) prior to the pins (13) being removed from the panel (12).

3. A method according to claim 1 or claim 2 characterised in that the pins (13) are driven into the composite panel (13) using mechanical pressure.

4. A method according to claim 1 or claim 2 characterised in that the pins (13) are driven into the composite panel (12) by pressure applied during curing of the panel.

5. A method according to anyone of the preceding claims characterised in that a protective sheet (15) is placed between the base (11) and the composite panel (12) placed thereon.

6. A method according to anyone of the preceding claims characterised in that the matrix of pins (13) is preformed to a shape which corresponds generally to the shape of the base (11), prior to the matrix being placed on the panel (12) such that each pin (13) extends generally normally to the panel (12).

7. A method according to any one of the preceding claims characterised in that the pins (13) are removed by chemical etching using a strong acid.

8. A method according to anyone of the preceding claims characterised in that the panel (12), at least when placed on the base (11), has a double curvature.

9. A method according to any one of the preceding claims characterised in that the composite panel (12) is a skin of an engine nacelle and the panel (12), subsequent to the pins (13) being removed therefrom, is attached to another component part of the nacelle.

10. A method according to any one of the preceding claims characterised in that the composite material of the panel (12) comprises fibres embedded in a resin material.

The Patent Office

10

Application No: GB 9705283.1 **Examiner:** J P Leighton
Claims searched: 1-10 **Date of search:** 3 June 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): B5A(AA2, AT9P, AT12A, AT12P, AT20P)

Int Cl (Ed.6): B26F(1/24); B29C(33/00, 67/14)

Other: Online:WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB2256611A	British Aerospace plc	
A	GB2025302A	Rolls-Royce Limited	
A	GB1352198A	General Electric Company	
A	EP0471459A1	Westland Aerostructures Ltd	
A	US5246520A	Auto-Air Composites Inc.	
A	US4486372A	Rohr Industries Inc.	

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
& Member of the same patent family
A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier than, the filing date of this application.